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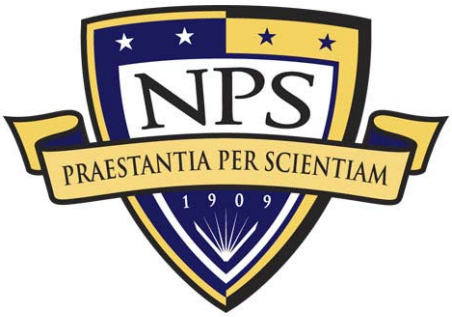

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An Empirical Analysis of the Patterns in Defense Industry Consolidation and Their Subsequent Impact

30 September 2007

by

Nayantara Hensel, Assistant Professor

Graduate School of Business & Public Policy

Naval Postgraduate School

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Abstract

The defense industry has witnessed significant consolidation since the end of the Cold War. This paper explores the causes of the wave of defense mergers, as well as their impact. The analysis finds that the frequency of defense mergers is more strongly correlated with overall merger activity in the economy than with DoD outlays. In examining SAR cost data on weapons systems, only 54-64% of the weapons systems' costs were affected following consolidation activity by the primary contractor that made them, of which 39-43% of the systems experienced a statistically significant decrease in their costs, and 14-21% experienced a statistically significant increase. Despite a 2/3 reduction in the number of prime contractors in the fixed wing aircraft sector between 1990 and 1998, about 43% of the systems experienced a statistically significantly lower cost estimate. For the tactical missile category, in which the number of prime contractors also fell by 2/3, 14.3% of the systems indicated statistically significantly higher post-merger estimates and 28.6% of them indicated statistically significantly lower post-merger estimates. Boeing, Lockheed, and Raytheon were among the few main primary contractors in several sectors following the consolidation wave. About 60% of the weapons systems examined in this analysis which were produced by them indicated a statistically significant change in their cost estimates. For Boeing and Lockheed, 50% of the systems exhibited a statistically significant reduction in cost estimates, while, for Raytheon, 40% of the systems experienced a significant cost increase. About 2/3 of the systems made by Lockheed and Martin Marietta manifested significant cost declines following the Lockheed-Martin Marietta merger, and about ½ of the systems made by Boeing and McDonnell Douglas experienced a statistically significant decline in cost estimates following the merger. This suggests that, although market concentration levels may have increased in certain sectors, DoD's costs often tended to be lower in the post-merger period for certain weapons systems.

Keywords: defense mergers; consolidation; efficiencies; cost data

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Nayantara Hensel, PhD, is an Assistant Professor of Economics and Finance at the Graduate School of Business and Public Policy at the US Naval Postgraduate School. She received her BA (magna cum laude) from Harvard University where she was a member of Phi Beta Kappa. She also received her MA and PhD in Business Economics (Applied Economics) from Harvard University. Prior to joining the faculty at the US Naval Postgraduate School, Dr. Hensel served as a Senior Manager at Ernst & Young, LLP and as the chief economist for one of its units, was a Post-doctoral Research Fellow at the National Bureau of Economic Research, taught at Harvard University and the Stern School of Business at NYU, and was an economist at NERA (part of Marsh & McLennan). Dr. Hensel's recent research has examined the impact of size and market structure on efficiency (economies of scale) in European and Japanese banks and on their tendency to open branches or merge, the impact of contracting arrangements and mergers on the utilization of railroad networks, the role of venture capital in the DoD, the determinants of discount rates for military personnel, and the impact of online auctions on IPO pricing efficiency. She has published in a variety of journals, including the *Review of Financial Economics*, the *International Journal of Managerial Finance*, the *European Financial Management Journal*, the *Journal of Financial Transformation*, *Business Economics*, and *Harvard Business School Working Knowledge*.

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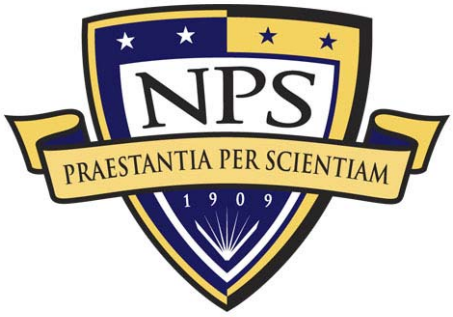

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Executive Summary

The defense industry has witnessed significant consolidation since the end of the Cold War. This paper explores the causes of the wave of defense mergers, as well as their impact. The analysis finds that the frequency of defense mergers is more strongly correlated with overall merger activity in the economy than with DoD outlays. In examining SAR cost data on weapons systems, only 54-64% of the weapons systems' costs were affected following consolidation activity by the primary contractor that made them, of which 39-43% of the systems experienced a statistically significant decrease in their costs, and 14-21% experienced a statistically significant increase. Despite a 2/3 reduction in the number of prime contractors in the fixed wing aircraft sector between 1990 and 1998, about 43% of the systems experienced a statistically significantly lower cost estimate. For the tactical missile category, in which the number of prime contractors also fell by 2/3, 14.3% of the systems indicated statistically significantly higher post-merger estimates and 28.6% of them indicated statistically significantly lower post-merger estimates. Boeing, Lockheed, and Raytheon were among the few main primary contractors in several sectors following the consolidation wave. About 60% of the weapons systems examined in this analysis which were produced by them indicated a statistically significant change in their cost estimates. For Boeing and Lockheed, 50% of the systems exhibited a statistically significant reduction in cost estimates, while, for Raytheon, 40% of the systems experienced a significant cost increase. About 2/3 of the systems made by Lockheed and Martin Marietta manifested significant cost declines following the Lockheed-Martin Marietta merger, and about ½ of the systems made by Boeing and McDonnell Douglas experienced a statistically significant decline in cost estimates following the merger. This suggests that, although market concentration levels may have increased in certain sectors, DoD's costs often tended to be lower in the post-merger period for certain weapons systems.

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I. Introduction

The defense industry has witnessed significant consolidation since the end of the Cold War. As the number of large defense contractors has declined, key public policy questions have arisen concerning whether the mergers have led to greater efficiencies, lower costs, and improvements in quality, or whether they have led to higher costs, fewer choices, and larger firms with unwieldy organizational structures. The purpose of this paper is to examine: (a) the roles of defense spending and broader merger activity in the economy on the frequency and size of defense mergers; (b) the patterns of defense consolidation and some of the related antitrust concerns; and (c) the impact of mergers of major defense contractors on the costs of weapons systems facing DoD.

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II.The Impact of Defense Spending and Broader Merger Activity on Defense Mergers

The wave of defense mergers, particularly during the 1990's, was partially driven by the need to eliminate excess capacity in the industry following the end of the Cold War. Overall defense spending, as well as defense procurement spending, grew rapidly during the 1980's, declined following the end of the Cold War, increased towards the end of the 1990's, and exhibited significant growth with the War on Terrorism. Indeed, overall defense spending grew 73.5%, and defense procurement spending grew 133.1% between 1981 and 1991, while between 1992 and 1996, overall defense spending fell 10.9% and defense procurement spending fell 34.7%. Between 1997 and 2001, overall defense spending and defense procurement spending grew 12.7% and 15.3%, respectively, while between 2002 and 2006, overall defense spending and defense procurement spending grew at 49.7% and 43.6%, respectively.[1] In constant FY 2001 dollars, overall defense spending declined 34.8% between FY 1985 and FY 1996 and declined 25.6% between FY 1990 and FY 1996. Defense procurement spending declined 67.2% between FY 1985 and FY 1996 and declined 53.77% between FY 1990 and FY 1996.[2]

The wave of mergers in the defense sector was also partially linked to overall merger patterns within the US economy. Table 1 shows the growth rate from year to year in terms of the number of defense mergers and the value of defense mergers, as compared to the comparable growth rates for merger activity in the US economy.

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[1] These growth rates were calculated by the author from the raw data in the Historical Tables (Table 3.2) for the *United States Budget for Fiscal Year 2008*, p. 56-60. The growth rates are not annualized nor adjusted for inflation.

[2] These growth rates were calculated by the author from the raw data in the *Annual Report to the President and Congress by the Secretary of Defense in 2000*, Appendix B-1. The growth rates are calculated from data in constant dollar terms, although they are not annualized.

Table 1: Annual Growth Rates in Merger Activity in the Defense Sector and in the Overall Economy

Time Period	Annual growth rates for merger activity (number of transactions) in the defense sector	Annual growth rates for merger activity (number of transactions) in the overall economy	Annual growth rates for merger activity ($ value) in the defense sector	Annual growth rates for merger activity ($ value) in the overall economy
1992-1993	-44.83%	4.008%	-82.37%	45.41%
1993-1994	-6.25%	12.66%	268.1%	80.63%
1994-1995	-33.00%	17.37%	-94.13%	30.94%
1995-1996	100.0%	66.51%	8571.4%	110.8%
1996-1997	50.00%	33.32%	-46.96%	35.68%
1997-1998	70.00%	0.154%	-59.25%	83.41%
1998-1999	0.00%	18.94%	169.0%	19.16%
1999-2000	-29.4%	3.28%	392.8%	832.9%
2000-2001	-5.5%	-13.37%	-97.03%	-94.72%
2001-2002	26.47%	-12.06%	164.7%	-37.42%
2002-2003	-34.88%	9.573%	-55.97%	15.14%
2003-2004	-10.7%	22.66%	50.50%	48.78%

These annual growth rates were calculated by the author from raw data found in *the Mergerstat Review for 2005, the Mergerstat Review for 2002, the Mergerstat Review for 1997*, and the *Mergerstat Review for 1996*. The defense sector, as defined by Factset Mergerstat, encompassed firms in Standard Industry Classification (SIC) codes 3761-3769, 3721-3728, and 3795.

Growth in merger activity in the defense sector, whether measured by growth in value or growth in number of transactions, was generally lower than growth in merger activity in the overall economy. Growth in merger activity in the defense sector exceeded growth in merger activity in the industry overall (or exhibited less negative growth) in terms of the number of transactions and in terms of value in 5 out of the 12 years (41.67%).

Table 2 shows the number of defense mergers which were over $100 million in value as a percentage of total defense mergers, as well as the percentage of larger mergers which were over $100 million in size in the economy as a percentage of total mergers in the economy. The years in which large defense mergers were over a quarter of the mergers in that sector were 1992, 1994, 1996, and 2004. In the

overall economy, large mergers tended to be a smaller percentage of the total number of mergers due to the total volume of mergers during the mid- to late 1990's.

Table 2: Percentage of Defense Mergers and Mergers in the Overall Economy Exceeding $100 Million in Value

Time Period	Number of $100m plus transactions as a percentage of total transactions in the defense industry	Number of $100m plus transactions as a percentage of total transactions in the overall economy
1991	0.00%	8.01%
1992	27.59%	7.54%
1993	18.75%	9.03%
1994	40.0%	12.64%
1995	0.00%	13.2%
1996	40.0%	10.84%
1997	20.0%	11.16%
1998	19.6%	11.55%
1999	13.73%	11.81%
2000	16.67%	12.00%
2001	17.64%	8.44%
2002	6.977%	8.33%
2003	10.71%	8.19%
2004	24.00%	8.60%

These percentages were calculated by the author from raw data found in the *Mergerstat Review for 2005, the Mergerstat Review for 2002, the Mergerstat Review for 1997*, and the *Mergerstat Review for 1996*. The defense sector, as defined by Factset Mergerstat, encompassed firms in Standard Industry Classification (SIC) codes 3761-3769, 3721-3728, and 3795.

Industry observers often cite defense spending and overall merger activity as the two forces behind defense sector mergers (Korb, 1996). But, is defense merger activity more linked to the level of DoD spending or to the overall level of merger activity in the economy? Which one of these is a more significant force? Table 3, which shows correlations between various measures of defense merger activity and merger activity in the overall economy, as well as between defense merger activity and DoD spending, suggests that defense merger activity is much more strongly

linked to overall activity in the economy. This supports the hypothesis that merger activity was not necessarily entirely driven by the need to downsize and reduce excess capacity in the wake of the Cold War.

The correlations use data covering the period between 1992 and 2004. The second column of Table 3 shows the correlations between the number of defense mergers in a given year and: (a) the overall level of DoD outlays in that year; (b) the level of DoD procurement outlays in that year; (c) the overall level of DoD outlays in the previous year; (d) the level of DoD procurement outlays in the previous year; and (e) the level of overall merger activity in the economy. The third column of Table 3 shows the comparable correlations for defense merger activity as measured by dollar value, rather than by number of transactions.

Table 3: Correlations between DoD Outlays, Merger Activity in the Economy, and Merger Activity in the Defense Sector

Correlation between:	Number of defense merger transactions in a given year	Dollar value of defense merger transactions in a given year
Level of overall DoD outlays in a given year	-0.0269	-0.2058
Level of DoD procurement outlays in a given year	-0.3591	-0.3783
Level of overall DoD outlays in the previous year	-0.1929	-0.2947
Level of DoD procurement outlays in the previous year	-0.6097	-0.3916
Number of mergers in the overall economy in a given year	0.6498	
Dollar value of mergers in the overall economy in a given year		0.9399

The statistical correlations were calculated by the author from raw data found in the Historical Tables (Table 3.2) for the *Budget for Fiscal Year 2008*, p. 56-50, and from the raw data found in the *Mergerstat Review for 2005, the Mergerstat Review for 2002, the Mergerstat Review for 1997*, and the *Mergerstat Review for 1996*.

The correlations between defense merger activity (regardless of how it is measured) and DoD outlays (regardless of whether it is measured in overall levels or

procurement levels, and whether it occurred in the current year or in the previous year) are negative, as would be expected—as defense spending goes down, defense merger activity goes up. Nevertheless, the correlations tend to be weak. Procurement outlays move much more strongly in the opposite direction from defense transactions than overall DoD outlays do. Correlating previous year DoD overall outlays and procurement outlays with current-year merger activity (in terms of either transactions or value) yields a stronger relationship than correlating current-year outlays with current-year merger activity. This suggests that, since the merger process requires time, mergers are a delayed response to spending levels in previous years. The tightest negative relationship is between merger activity (as measured by the number of transactions) and DoD procurement outlays in the previous year.

The correlations are strongly positive between merger activity in the defense sector and merger activity in the overall economy in a given year (excluding defense mergers)—as one increases, the other also increases. The correlation is strongly positive between the number of defense mergers and the number of mergers in the economy overall (excluding defense mergers) at 0.6498, while the correlation is very strongly positive between the dollar value of mergers in the overall economy (excluding defense mergers) and the dollar value of defense mergers at 0.9399.

In summary, Table 3 suggests that although the wave of defense mergers was driven by both DoD spending and by overall economic merger activity, overall economic merger activity was much more strongly correlated. Consequently, the decline in Cold War spending and its impact on excess capacity was less important than overall economic growth, stock market conditions, and the need for defense firms to defensively merge as their rivals merged so that they would not be left out in the cold as a relatively smaller firm facing larger, consolidated competitors.

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III.Patterns of Defense Consolidation and Antitrust Concerns

In July, 1993, Deputy Defense Secretary William Perry, at a summit known as the “Last Supper,” met with representatives of the major defense contractors and encouraged significant defense sector consolidation (Ricks & Cole, 1998; Cole, 1996). Between 1990 and 1998, the number of prime contractors decreased significantly due to consolidation in 10 of the 12 key defense sectors identified by DoD. These 10 sectors included: tactical missiles, fixed-wing aircraft, expendable launch vehicles, satellites, surface ships, tactical wheeled vehicles, tracked combat vehicles, strategic missiles, torpedoes, and rotary-wing aircraft. Table 4 shows, for each of the 10 sectors, the number of prime contractors in 1990, the number of prime contractors in 1998, and the amount of the percentage decline.

Table 4: Reduction in Prime Contractors in Various Weapons Systems Sectors between 1990 and 1998

Sector	Number of prime contractors in 1990	Number of prime contractors in 1998	Percentage reduction
Tactical Missiles	13	4	-69.2%
Fixed-wing Aircraft	8	3	-62.5%
Expendable Launch Vehicles	6	2	-66.7%
Satellites	8	5	-37.5%
Surface Ships	8	5	-37.5%
Tactical Wheeled Vehicles	6	4	-33.3%
Tracked Combat Vehicles	3	2	-33.0%
Strategic Missiles	3	2	-33.0%
Torpedoes	3	2	-33.0%
Rotary-wing Aircraft	4	3	-25.0%

Data on the sectors and the number of contractors in 1990 and 1998 are derived from the General Accounting Office (GAO) Report to Congressional Committees on the Defense Industry: Consolidation and Options for Preserving Competition from April, 1998.

The percentage reduction in contractors exceeded 60% in 3 of the 10 sectors, and varied between 25% and 37.5% in the remaining 7 of the 10 sectors. The major giants which emerged out of this consolidation across these sectors were Boeing, Lockheed Martin, and Northrop Grumman, and, to a lesser degree, Raytheon and General Dynamics. Between 1990 and 1998, the three sectors which experienced the most consolidation, and which were dominated by contractors which only included Boeing, Lockheed Martin, Northrop Grumman, and Raytheon, were: tactical missiles, fixed-wing aircraft, and expendable launch vehicles.

By 1998, Boeing was one of the prime contractors in 6 of the 10 markets: tactical missiles, fixed-wing aircraft, expendable launch vehicles, satellites, strategic missiles, and rotary-wing aircraft. Lockheed Martin was one of the prime contractors in 5 of the 10 sectors: tactical missiles, fixed-wing aircraft, expendable launch vehicles, satellites, and strategic missiles. Northrop Grumman was one of the prime

contractors in 3 of the 10 sectors: tactical missiles, fixed-wing aircraft, and torpedoes. General Dynamics was one of the prime contractors in 2 of the 10 markets: tracked combat vehicles and surface ships. Finally, Raytheon was one of the prime contractors in 2 of the 10 markets: tactical missiles and torpedoes.

With the increasing numbers of defense mergers in the mid- to late 1990's, the Antitrust Division of the Department of Justice (DOJ) and the Federal Trade Commission (FTC) became more concerned that consolidation was leading to a reduction in competition and an increase in anticompetitive activity. As Joel Klein, Assistant Attorney General of the Antitrust Division of the DOJ noted in his address before the Senate Judiciary Committee in June, 1998, "A number of defense mergers proceeded unchallenged over the last 5 years, which rationalized capacity, but if that rationalization goes too far, it can harm competition" (Klein, 1998, p.7). Indeed, the DOJ had challenged two mergers in 1997— Raytheon's acquisition of Hughes Aircraft (the aircraft subsidiary of General Motors) and Raytheon's acquisition of the defense electronics division of Texas Instruments—but then allowed both of them to go through provided that divestitures of certain key divisions occurred prior to the merger in order to protect competition. In 1998, however, the DOJ blocked the merger between Lockheed Martin and Northrop Grumman, since the DOJ believed that the merger would lead to a reduction in competition and innovation in submarine sonar systems, military aircraft radar, and various electronic warfare systems. This proposed $11.6 billion acquisition was the largest acquisition that the DOJ had challenged in its history up to that point (Klein, 1998), and the challenge was supported by the Pentagon since Defense Secretary Cohen also thought that the merger would be anticompetitive (Ricks & Cole, 1998). Lockheed and Northrop called off the merger in July, 1998, prior to their September trial date (Fidler & Lewis, 1998).

Analyzing the anticompetitive impact of consolidation in the defense sector involves different considerations from analyzing consolidation in other industries for several reasons. First, in determining the relevant geographic market of possible

competitors, the analysis can't always include foreign weapons manufacturers for security reasons, although, in other industries, foreign manufacturers can be included in defining the boundaries of the market that would be affected by the merger. Second, traditional industries have a broader spectrum of consumers for the product, whereas DoD is the main buyer for weapons systems. Consequently, it plays a highly significant role in the DOJ and FTC deliberations. Third, lower barriers to entry would allow new entrants to enter the market and reduce the possible anticompetitive effects of increased consolidation, such as higher pricing. Nevertheless, the government contracting process makes it harder for new entrants to gain a foothold and tends to give an advantage to incumbent firms, which know the government contracting system better.

Either vertical or horizontal consolidations could contribute to a negative outcome. Vertical mergers might lead to foreclosure to competitors of key input suppliers or distributors along the vertical supply chain. For example, one of the concerns about the proposed Lockheed Martin-Northrop Grumman merger had been that Lockheed Martin would have control of a key supplier of electronics which supplied Boeing's planes, as well as its own planes. This could enable it to limit Boeing's access to the supplier. On the other hand, Lockheed argued that the Pentagon could monitor the selections of equipment from outside suppliers and that the process was sufficiently transparent that this would not be an issue. Indeed, Lockheed argued that the mission computers in its F-16 planes came from Raytheon (Ricks & Cole,1998). A second example of concerns over vertical integration was when the CEO of McDonnell Douglas, in April, 1996, announced that McDonnell Douglas would stop buying parts from Loral for its jet fighters once Lockheed Martin acquired Loral. Paul Kaminski, the chief of procurement at the Pentagon, wrote to McDonnell Douglas, stating that this could '"increase the cost or lower the quality of the products you supply"' and that if the best product is offered by a given supplier, which '"happens to be Loral, then McDonnell Douglas should continue to buy from that company"' (Cole,1996).

Horizontal mergers, in the absence of viable international competition or entry by new companies, could lead to increased market power and higher prices in certain sectors. For example, one of the concerns with Raytheon's acquisition of Hughes Aircraft and the defense divisions of Texas Instruments in 1997 was that these acquisitions would provide Raytheon with a near monopoly position in spy satellite sensors, night vision equipment, and air-to-air missiles. Hughes and Raytheon had previously been strong competitors for missile contracts, and, according to the chief of acquisitions at the Pentagon, Paul Kaminiski, "their competition saved taxpayers hundreds of millions of dollars, shaving 70 percent from Hughes' original price." Raytheon, on the other hand, had argued that other companies had competed in missile competitions and had won, citing McDonnell Douglas' and Lockheed Martin's success in bidding for the JASSM missile contract (Mintz,1997).

On the other hand, consolidation might also lead to more innovative or less costly weapons systems due to greater pooling of knowledge between consolidating contractors. For example, Boeing, which had acquired Rockwell and McDonnell Douglas, succeeded over Lockheed in winning a $5 billion contract for a National Reconnaissance Satellite in 1999. At the time, some argued that the combination of knowledge and talent between McDonnell Douglas, Rockwell, and Boeing enabled the unified entity to win the contract and that this would not have been possible without consolidation (Flanigan, 1999). A second example is when the Navy in early September, 1997 thought that the proposed merger between Lockheed Martin and Northrop Grumman would have actually enabled Lockheed, which had a weaker background in building naval aircraft, to compete more effectively against Boeing in the competition for the new Joint Strike Fighter (Ricks & Cole, 1998). The merger, as discussed earlier, did not take place.

Consolidation activity also could lead to improved cost efficiencies from reduced overhead costs—combining duplicative facilities and corporate headquarters, rationalizing and reducing the workforce, pooling R&D funds, and

more effectively using pre-existing capacity. Indeed, when the Lockheed-Martin Marietta merger took place in 1995, it was estimated that merging telecommunications operations, research divisions, and headquarters, would save $3 billion over the following five years (Mintz, 1994). Some of the mergers clearly failed to yield their projected saving, however. For example, Martin Marietta's 1993 acquisition of General Electric Aerospace had only yielded half of the expected cost savings three years later, according to the GAO (Foote, 1996). Two years after the union of Hughes Aircraft and General Dynamics' missile division in 1992, the Inspector General could not verify that the consolidation had saved the projected $600 million for the Pentagon (Korb, 1996).

Has the wave of defense mergers led to cost savings for DoD? According to the *Los Angeles Times* in October, 1999, "Almost a decade of consolidation in the defense industry has failed to deliver the benefits of lower costs for the Pentagon. And the mergers of the '90's that were supposed to produce stronger and more innovative defense contractors have more often caused corporate indigestion" (Flanigan, 1999). Industry observers argued that innovation had suffered from the mergers, and that the companies had become too big and were expending significant effort in managing themselves (Flanigan, 1999).

The issue of whether DoD recognized cost savings from the wave of consolidation was further complicated by its decision to pay the restructuring costs of consolidation beginning in July, 1993 provided that certain conditions from the consolidation were met, such as that the projected savings from the restructuring would exceed the costs. Under the 1997 *DoD Appropriations Act,* projected savings needed to exceed costs by a ratio of two to one for business combinations occurring after September 30, 1996, in order for restructuring costs to be reimbursed (Cooper, 1997). In 1997, DoD calculated that, through September 30, 1996, for every $1.00 that it paid in restructuring costs, it estimated $1.93 in savings because it had paid $179.2 million in restructuring costs and realized savings of $346.7 million. Nevertheless, in several of the five business combinations reviewed, savings was

much less than the contractors had actually estimated. For Lockheed Martin, the estimated savings used to certify the Lockheed-Martin Marietta merger as eligible for restructuring, as of September 30, 1996, was less than half of the savings estimate which had originally been projected (Cooper, 1997).

IV. Analysis of Cost Data on Weapons Systems by Type and by Defense Contractor

This analysis examines whether cost estimates for weapons systems made by leading defense contractors increased or decreased following a merger with another major defense contractor. The analysis used cost data from the summary tables in the *Selected Acquisition Reports* (*SARS*) which are submitted to Congress by DoD and which report the acquisition costs of Major Defense Acquisition Programs (MDAPS).[3] Each *SAR* contains a variety of various items on the mission of the weapons system and the contractors involved, as well as data on the costs of the weapons system, including baseline cost estimates and quantity estimates, current cost estimates and quantity estimates, and a decomposition of cost changes into quantity cost changes, schedule cost changes, engineering cost changes, support cost changes, estimating cost changes, and other cost changes. The period covered in the *SAR* data used in this analysis encompassed March, 1981 until June, 2006.

The analysis examined 28 weapons systems/programs; this is only a subset of the weapons programs available in the *SARS*. These systems were selected because: (a) the primary contractor was involved in a merger with a major defense

[3] MDAP (Major Defense Acquisition Program)—"Defined in 10 USC § 2430 as a Department of Defense (DoD) acquisition program that is not a highly sensitive classified program (as determined by the Secretary of Defense) and that is designated by the Secretary of Defense as a major defense acquisition program, or that is estimated by the Secretary of Defense to require an eventual total expenditure for research, development, test, and evaluation of more than $365,000,000 (updated to FY 2000 constant dollars) or an eventual total expenditure for procurement of more than $2,190,000,000 (updated to FY 2000 constant dollars)." (Department of Defense, 2006, August 3)

contractor during the period covered; (b) there was enough time-series data to examine the pre-merger and the post-merger period; (c) the weapons system was only made for one of the services; and (d) the contract for the weapons system, during the period covered, did not have a defense contractor that was not involved in the merger as its primary contractor. The research is still ongoing, and it is expected that more weapons systems/programs will be included in an expanded version of this preliminary study.

This analysis examines the current-year cost estimates in base-year dollars of each weapons system/program over time. This is because current-year cost estimates in base-year dollars capture overall pre- and post-merger effects better than other variables in the *SARS,* which decompose the cost change into quantity changes, schedule changes, engineering changes, etc. A merger could impact cost estimates through any of these avenues, so year-to-year changes in overall current-year cost estimates in base-year dollars provided the best measure. An expanded version of this preliminary study intends to examine the other components of the cost change decomposition in greater detail. Current-year cost estimates in base-year dollars were also used to minimize the impact of inflation.

The regression model used for each of the 28 weapons systems/programs regressed current-year cost estimates in base-year dollars for a given weapons system on a time-trend variable and on an indicator variable that took on the value of "1" after the merger of its primary contractor and "0" before the merger. The time trend controlled for the increases in cost estimates over time. The regression model appears below:

$$(\text{Current-year cost estimates in base-year dollars})_i = \alpha + \beta_1 (\text{time trend})_i + \beta_2 (\text{post-merger indicator variable})_i$$

The regression was run over the time-series data for each weapons system. In one set of regressions, the post-merger effect was assumed to take place beginning with the report date of the *SAR* nearest chronologically to the effective

date of the merger. In the second set of regressions, the post-merger effect was assumed to take place beginning with the report date of the *SAR* which was the second nearest chronologically to the effective date of the merger. Although the timing of the impact of a merger on *SAR* cost estimates can vary between contractors and weapons systems, the analyses focused on the nearest *SAR* or the second-nearest *SAR* to the merger date for consistency.

Tables 5 and 6 show that the empirical results are largely robust, regardless of whether the post-merger effect is assumed to occur beginning with the *SAR* nearest chronologically to the effective merger date or beginning with the second-nearest *SAR* to the effective merger date. The first column includes the name of the weapons system; the second column gives the coefficient (and its sign) for the post-merger indicator variable; the third column provides the p-value for the statistical significance of the post-merger effect on cost estimates; the fourth column gives the coefficient (and sign) on the time trend, and the fifth column provides the p-value for the statistical significance of the time trend.

Table 5: Regression Results with the Post-merger Effect Beginning at the *SAR* Nearest to the Effective Date of the Merger

Weapons System	Coefficient on post-merger indicator variable	P-value on coefficient for post-merger indicator variable	Coefficient on time trend variable	P-value on coefficient for time trend variable
AH-64	36.9611	0.763	47.257	0.000
AIM-9X	1554.8	0.000	4.8778	0.568
ASAS	-1419.66	0.000	16.395	0.046
AMRAAM	-2826.00	0.000	183.26	0.000
ATACMS	134.47	0.366	29.903	0.000
AV-8B	-113.64	0.001	6.5453	0.005
ATCCS	179.68	0.046	-12.833	0.003
ATICRM	-49.355	0.899	64.324	0.007
C-17	17687.66	0.000	319.77	0.000
DDG-51	-6357.78	0.001	740.82	0.000
FA-18	-21133.99	0.002	635.6	0.014
F-22	-8867.30	0.151	1074.1	0.000
Javelin	-78.669	0.840	14.043	0.291
JDAM	-669.47	0.032	147.651	0.000
JSOW	542.25	0.609	-9.9954	0.827
JSTARS	-1396.20	0.003	168.99	0.000
LHD-1	251.02	0.210	53.764	0.000
Longbow Apache	-381.75	0.612	149.51	0.000
Longbow Hellfire	-759.73	0.033	36.382	0.008
NAVSTAR User Equipment	-212.399	0.013	29.502	0.000
Titan IV	-9604.985	0.000	504.366	0.000
DMSP	15.714	0.322	6.557	0.000
FBCB2	-422.658	0.180	4.646	0.876
MLRS	-28.854	0.744	28.307	0.000
Strategic Sealift Program	58.530	0.685	20.624	0.029
T45TS	143.59	0.401	47.809	0.000
Trident	-2111.671	0.056	10.3506	0.679
JPATS	744.526	0.047	124.02	0.000

Table 6: Regression Results with the Post-merger Effect Beginning at the Second Nearest *SAR* to the Effective Date of the Merger

Lagged	Coefficient on post-merger indicator variable	P-value on coefficient for post-merger indicator variable	Coefficient on time trend variable	P-value on coefficient for time trend variable
AH-64	87.88	0.48	45.65	0.000
AIM-9X	1279.3	0.000	9.408	0.422
ASAS	-1004.9	0.002	-8.205	0.733
AMRAAM	-2953.6	0.000	184.6	0.000
ATACMS	234.6	0.108	27.20	0.000
AV-8B	-116.95	0.001	7.088	0.004
ATCCS	194.91	0.033	-13.60	0.002
ATICRM	255.64	0.504	49.295	0.031
C-17	17138.7	0.000	336.68	0.000
DDG-51	-7478.1	0.000	761.47	0.000
FA-18	-24329.8	0.000	751.15	0.003
F-22	-11220	0.067	1127.4	0.000
Javelin	1156.99	0.002	-22.196	0.067
JDAM	-698.65	0.028	149.39	0.000
JSOW	1631.28	0.126	-50.687	0.276
JSTARS	-1300.27	0.005	166.48	0.000
LHD-1	144.32	0.476	55.225	0.000
Longbow Apache	-669.24	0.372	158.10	0.000
Longbow Hellfire	-789.56	0.030	38.132	0.007
NAVSTAR User Equipment	-191.89	0.024	28.756	0.000
Titan IV	-10094.5	0.000	513.14	0.000
DMSP	30.865	0.041	5.910	0.000
FBCB2	-606.34	0.056	22.475	0.456
MLRS	-34.901	0.693	28.377	0.000
Strategic Sealift Program	93.856	0.506	19.345	0.028
T45TS	63.6989	0.707	49.373	0.000
Trident	-1489.63	0.178	-2.125	0.933
JPATS	947.42	0.006	118.27	0.000

Table 7 summarizes the findings of Tables 5 and 6. Again, there is little difference between the findings if the merger effect is assumed to begin at the *SAR*

closest to the merger effective date and the findings if the merger effect is assumed to begin at the second nearest *SAR* to the merger effective date. Between 54% and 64% of the systems examined in the analysis experienced a statistically significant change in their cost estimates following a merger, controlling for the time trend. Between 39% and 43% of the systems experienced a statistically significant negative reduction in cost estimates in the post-merger period, controlling for the time trend, while between 14% and 21% of the systems experienced a positive, statistically significant cost increase. This suggests that defense mergers did not always experience a statistically significant change in their cost estimates post-merger, but that, for those systems that did, the cost estimates were more likely to decrease than to increase, even controlling for the time trend.

Table 7: Percentage of Weapons Systems Experiencing a Post-merger Change in Cost Estimates

	Percentage of systems experiencing a positive and statistically significant change	Percentage of systems experiencing a negative and statistically significant change	Percentage of systems experiencing a statistically significant change
Post-merger effect begins at the *SAR* closest to the merger effective date	14.3%	39.3%	53.6%
Post-merger effect begins at the second nearest *SAR* to the merger effective date	21.4%	42.9%	64.3%

Table 8 summarizes the weapons systems findings from Table 5 and categorizes those results based on the type of weapons system classification found in the 1998 GAO report, although this analysis added the strategic electronics sector

and the munitions sector. The classification of the weapons systems into these broader categories was done by examining the description of the weapons systems in the *SARS*, consulting *Jane's*, reading materials written by the defense contractors, examining *The 2007-2008 Weapons Systems* from the Office of the Assistant Secretary of the Army for Acquisitions, Logistics, and Technology, and reading detail on each system written by the Federation of American Scientists.

The categories which were most affected by the mergers (in the sense that 40-70% of the weapons systems in those categories exhibited a statistically significant post-merger change in cost estimates) were the strategic electronics category, the tactical missile category, and the fixed-wing aircraft category. About 29-43% of those systems exhibited a statistically significant reduction in cost estimates, controlling for the time trend. Based on the data in Table 4, the number of prime contractors in the fixed-wing aircraft sector experienced a 62.5% decline between 1990 and 1998. Consequently, this analysis suggests that although market concentration in the fixed-wing aircraft sector increased, this led to more significant cost decreases than cost increases in weapons systems. The evidence is similar for the tactical missile category, in which, based on the data in Table 4, the number of contractors declined 69.2% between 1990 and 1998. About 43% of the weapons in the tactical missile category exhibited statistically significant changes in their cost estimates, of which 14.3% of them exhibited significant increases, and 28.6% of them exhibited significant decreases. The number of prime contractors in the surface ships category declined 37.5%, but the only system in that category that manifested a significant change exhibited a cost decline. The analysis had fewer systems in the rotary aircraft, strategic missile, munitions, and satellite categories, but a subsequent expanded version of the analysis hopes to include more systems in these categories.

Table 8: Percentage of Weapons Systems Experiencing a Post-Merger Change in Cost Estimates by Equipment Type

	Percentage of systems in each category which experienced a statistically significantly higher cost estimate post-merger	Percentage of systems in each category which experienced a statistically significantly lower cost estimate post-merger	Percentage of systems in each category which experienced a statistically significantly different estimate post-merger (higher or lower)
Rotary Aircraft	0%	0%	0%
AH-64			
Longbow Apache			
Tactical Missile	14.3%	28.6%	42.9%
AIM-9X			
AMRAAM			
ATACMS			
Javelin			
JSOW			
Longbow Hellfire			
MLRS			
Strategic Electronics	20%	40%	60%
ASAS			
NAVSTAR User Equipment			
FBCB2			
ATCCS			
ATICRM			
Fixed Wing Aircraft	28.6%	42.8%	71.4%
AV-8B			
C-17			
FA-18			
F-22			
JSTARS			
T45TS			
JPATS			
Surface Ships	0%	33%	33%
DDG-51			
LHD-1			
Strategic Sealift Program			
Satellite	0%	0%	0%
DMSP			
Munition	0%	100%	100%
JDAM			
Strategic Missile	0%	100%	100%
Titan IV			
Trident			

Table 9 summarizes the results in Table 5 by defense contractor. About 60% of the weapons systems made by Boeing, Raytheon, and Lockheed experienced statistically significant changes in their cost estimates following their mergers. Raytheon is the only one of the major contractors which had a higher percentage of weapons systems (40%) that experienced a statistically significant cost increase than the percentage of weapons systems (20%) that experienced a statistically significant cost decrease. About half of the weapons systems made by Lockheed, General Dynamics, and Boeing experienced a statistically significantly lower post-merger cost estimate. As discussed earlier, by 1998, Boeing was one of the prime contractors in 6 of the 10 markets, and Lockheed Martin was one of the prime contractors in 5 of the 10 markets. Again, this evidence suggests that although these contractors were obtaining greater market share through their consolidation, the mergers were more likely to reduce cost estimates for the weapons systems than to increase them. Raytheon is the exception, but it was one of the prime contractors in only 2 of the 10 markets (as delineated by the 1998 GAO report) and so had less opportunity for market power than Lockheed Martin and Boeing.

Table 9: Summary of Statistically Significant Cost Changes by Defense Contractor

	Percentage of systems made by each defense contractor which experienced a statistically significantly higher cost estimate post-merger	Percentage of systems made by each defense contractor which experienced a statistically significantly lower cost estimate post-merger	Percentage of systems made by each defense contractor which experienced a statistically significantly different estimate post-merger (higher or lower)
Northrop	0%	20%	20%
Boeing	12.5%	50%	62.5%
General Dynamics	0%	50%	50%
Raytheon	40%	20%	60%
Lockheed	12.5%	50%	62.5%

Table 10 explores the impact of the merger between Lockheed and Martin Marietta (effective on March 16, 1995) and the merger between Boeing and McDonnell Douglas (effective on August 1, 1997) on the weapons systems produced by these prime contractors for which sufficient data was available. The Lockheed-Martin Marietta merger impacted over 2/3 of the weapons systems examined, all of which experienced a statistically significant decline in cost estimates, controlling for the time trend. The Boeing-McDonnell Douglas merger impacted 50% of the weapons systems examined, of which all of them experienced a statistically significant decline in cost estimates, controlling for the time trend.

Table 10: Impact of Selected Defense Mergers on Weapons Systems Cost Estimates

	Percentage of systems made by the defense contractors involved in a specific merger which experienced a statistically significantly higher cost estimate post-merger	**Percentage of systems made by defense contractors involved in a specific merger which experienced a statistically significantly lower cost estimate post-merger**	**Percentage of systems made by the defense contractors involved in a specific merger which experienced a statistically significantly different estimate post-merger (higher or lower)**
Lockheed/Martin Marietta (March 16, 1995)	**0%**	**66.7%**	**66.7%**
ASAS			
F-22			
Longbow Hellfire			
Titan IV			
DMSP			
Trident			
Boeing/McDonnell Douglas (August 1, 1997)	**0%**	**50%**	**50%**
AV-8B			
C-17			
FA-18			
JDAM			
Longbow Apache			
T45TS			

V. Conclusions

This study examines evidence on the causes and the results of the defense merger wave of the late 1990s. Although the analysis is by no means exhaustive, it does suggest several key findings.

First, defense mergers are negatively correlated with DoD procurement outlays. The correlation between defense mergers in a given year and DoD procurement outlays in the previous year are stronger than correlations of measures in the current year. This suggests that merger activity is more likely to be a delayed response to previous spending levels than to current spending levels.

Second, the correlations between defense merger activity and overall merger activity in the economy are strongly positive. On balance, the correlations between defense merger activity and overall merger activity are much stronger than the correlations between defense merger activity and DoD outlays. This suggests that merger activity was driven less by declines in spending following the Cold War, and more by a stronger economy and a vibrant financial market.

Third, the reduction in the number of prime contractors between 1990 and 1998 was more substantial in certain sectors than in others and resulted in some of the defense contractors becoming dominant across sectors. The tactical missiles, fixed-wing aircraft, and expendable launch vehicle sectors experienced a 2/3 reduction in the number of prime contractors during the period. The major giants which emerged from the consolidation were Boeing (one of the prime contractors in 6 of the 10 sectors), Lockheed Martin (one of the prime contractors in 5 of the 10 sectors), and Northrop Grumman (one of the prime contractors in 3 of the 10 markets).

Fourth, in examining the *SAR* cost data on 28 weapons systems, only 54-64% of them exhibited a statistically significant post-merger cost change, which suggests that many weapons systems' estimates were unaffected by the mergers.

About 39-43% of the weapons systems examined in this analysis experienced a statistically significant decrease in cost estimates, controlling for the time trend, and about 14-21% of the systems experienced a statistically significant increase in cost estimates. This suggests that, to the extent that the weapons systems were impacted by mergers, a greater proportion of them experienced a reduction in costs rather than an increase in costs.

Fifth, when the weapons systems are classified into the 10 categories discussed in the 1998 GAO Report (with two additional categories), the fixed-wing aircraft, strategic electronics, and tactical missile categories had the highest percentage of systems which experienced a statistically significant post-merger change. Within the fixed-wing aircraft sector, about 40% of the systems experienced a statistically significantly lower cost estimate during the post-merger period. In the tactical missile category, 28.6% of the systems surveyed experienced a statistically significantly lower post-merger cost estimate, and 14.3% of the systems experienced a statistically significantly higher post-merger cost estimate. This suggests that in the fixed-wing aircraft sector and in the tactical missile sector, the increase in market concentration did not result in higher costs for DoD.

Sixth, when the weapons systems were identified with their primary contractor, around 60% of the weapons systems examined in this analysis which were produced by Boeing, Raytheon, and Lockheed experienced a statistically significant change in their cost estimates. For Boeing and Lockheed, 50% of the systems experienced a statistically significant reduction in cost estimates. Raytheon was the only contractor for whom 40% of the systems experienced a statistically significant increase in their cost estimates. This suggests that the increases in market power may not have translated into higher costs for DoD, especially for systems made by Lockheed and Boeing. Indeed, 2/3 of the systems made by Lockheed and Martin Marietta experienced a statistically significant decline in cost estimates following their merger. Half of the systems made by Boeing and

McDonnell Douglas experienced a statistically significant decline in cost estimates following their merger.

In conclusion, the analysis suggests that, although market concentration levels in certain sectors increased due to the wave of defense mergers, DoD's costs across weapons systems tended to be lower in the post-merger period. Although further research on a larger sample of weapons systems distributed across various sectors is necessary to more fully inform the public policy discourse, this study indicates that increases in market power do not necessarily lead to an anticompetitive outcome in pricing. Additional research on innovation cycles within the weapons systems is necessary, as well as a greater assessment of the degree to which international competition or the possibility of entry of smaller competitors in some of these sub-sectors constrained cost increases. Many of the questions and concerns in the earlier rounds of consolidation may emerge if a second round begins, possibly at a more global level; therefore, an assessment of the strengths and weaknesses of the most recent round of mergers during the late 1990's is crucial.

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